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Original Article

Association between multiple sleep dimensions and functional bowel disorders among Chinese college freshmen

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ABSTRACT

Background: Although sleep disorder is thought as a risk factor for functional bowel disorders, its impact role in adolescents remains unknown and the contribution of different sleep dimensions may deserve further attention. This study aimed to evaluate the relationship between multiple sleep dimensions and functional bowel disorders among Chinese college freshmen.

Methods: A cross-sectional survey was conducted in college freshmen from Huazhong University of Science and Technology in Wuhan, China in September 2019 with random cluster sampling method. All participants completed questionnaires about living habits, sleep and digestive symptoms. Diagnosis of irritable bowel syndrome and functional constipation were based on the Rome IV criteria. Univariate and multivariate logistic regression models were applied to assess the association of sleep dimensions with irritable bowel syndrome or functional constipation.

Results: Based on the 3335 individuals who completed the questionnaire, the overall prevalence of irritable bowel syndrome and functional constipation in college freshmen were 2.5% and 1.7%, respectively. Multivariate analysis revealed that compared with individuals reporting good sleep quality, those reporting poor (OR = 7.269, 95%CI: 2.876–18.370) were associated with increased risk of irritable bowel syndrome. Similarly, those reporting fair (OR = 2.068, 95%CI: 1.010–4.236) and poor (OR = 5.664, 95%CI: 1.864–17.205) were associated with increased risk of functional constipation. There was no statistically significant association between other sleep dimensions (sleep duration, sleep timing, or sleep latency) and irritable bowel syndrome or functional constipation.

Conclusion: Self-reported poor sleep quality was a stronger independent predictor of functional bowel disorders than other sleep dimensions among Chinese college freshmen. Future intervention studies should consider the role of sleep quality for the prevention of FBDs in adolescents.

1. Introduction

Functional bowel disorders (FBDs) are a spectrum of chronic bowel disorders characterized by symptoms of abdominal pain, bloating, distention and abnormal bowel habits in the lower gastrointestinal tract [1]. Irritable bowel syndrome (IBS) and functional constipation (FC) are the most common FBDs clinically. Meta-analysis revealed that pooled global prevalence of IBS and FC were 11.2% (95%CI: 9.8%–12.8%) [2] and 14.0% (95%CI: 12.0%–17.0%) [3], respectively. Moreover, recent studies raised the attention of the heavy burden of FBDs in adolescents nowadays [4,5]. These disorders can not only negatively affect patients' quality of school life [6], but also lead to increased costs of gastrointestinal healthcare [7].

Sleep disorder is often indicated as a significant risk factor for FBDs, whose nature is gut–brain interaction disorders. For example, studies have found that IBS and FC patients had higher prevalence of sleep disorder or excessive daytime sleepiness,

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compared with healthy controls [8,9]. In addition, sleep disorder is linked to diarrhea, loose stools, constipation and other lower gastrointestinal symptoms [10]. Mechanism studies have shown that disturbed sleep quality, inappropriate sleep duration as well as irregular sleep timing may interfere with circadian rhythms [11,12], immune function [13,14] and hormone secretion [15,16], therefore participating in the pathogenesis of various gastrointestinal diseases including FBDs. However, most epidemiological studies concentrated on the association of sleep quality with FBDs [17–19], and the contribution of other sleep dimensions (e.g. sleep duration, sleep timing, and sleep latency) still remains to be elucidated. In an earlier cross-sectional study, Kim et al. [20] demonstrated that rotating shift work was associated with increased risk of IBS, and this association persisted even when sleep quality was controlled, indicating that dimensions like sleep timing may also be important predictors of FBDs. Thus, it is of great significance to reveal the role of different sleep dimensions in FBDs for exploring more suitable methods of early intervention.

Sleep patterns in adolescents are unique, as they tend to have delayed bedtimes at night and shorter sleep duration, and this effect develops further with age and continues well into young adulthood, particularly for Asian adolescents [21,22]. Besides, increased prevalence of sleep disorder such as daytime sleepiness and sleep-onset insomnia were found in adolescents, partially due to their strict school schedules and high academic stress [21,23,24]. Sleep disorder and alterations in sleep patterns during adolescence are associated with a series of mental and physical health consequences different from adults, including poor mood, metabolic disorders, altered brain development and problems with attention and behavior [24–26]. To the knowledge of the present authors, few studies have explored the impact of sleep on the risk of FBDs in adolescents and the contribution of different sleep dimensions in this population.

In the present study, we investigated the prevalence of IBS and FC based on a random sample of adolescent college freshmen, and assessed the association of different sleep dimensions (sleep quality, sleep duration, sleep timing, and sleep latency) with IBS or FC.

2. Methods

2.1. Participants

This cross-sectional study was conducted in college freshmen who were admitted to Huazhong University of Science and Technology (HUST) in Wuhan, China in September 2019. Using cluster sampling method, schools or departments of HUST were randomly selected. All freshmen from the selected schools or departments gathered in classroom and were required to complete standard questionnaires voluntarily and anonymously. 4000 questionnaires were distributed initially and 3389 were submitted at last. Informed consents were obtained from all participants, and the study was approved by The Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology (No: IORG0003571).

2.2. Questionnaires

2.2.1. Demographic information and living habits

Demographic information (age, sex, height, and weight) and living habits (smoking status, drinking status, and physical activity) were collected. Body mass index (BMI) was calculated by dividing weight by the square of height (kg/m^2). Smoking status was categorized as current/former smokers and nonsmokers, and current smokers were defined as those who have smoked at least one cigarette per day in the previous six months. Drinking status was categorized as current/former drinkers and nondrinkers, and current drinkers were defined as those who have drunk at least once per week in the previous six months. Regular exercise was defined as those who have exercised for at least 20 min per day and at least three times per week over the past six months.

2.2.2. Assessment of sleep dimensions

Different sleep dimensions were investigated, including sleep quality, sleep duration, sleep timing, and sleep latency. Participants were asked to answer the following questions: (1) in the past six months, how do you feel about your sleep quality during the night? (2) in the past six months, what time do you usually go to sleep at night? (3) in the past six months, what time do you usually wake up in the morning? (4) in the past six months, how long does it usually take you to fall asleep? Sleep quality was classified into three categories: good, fair and poor. Sleep duration was classified into four categories: >8 h, 7–8 h, 6–7 h and ≤6 h. Sleep timing was classified into four categories: <11:00 PM, 11:00 PM-12:00 PM, 12:00 PM-1:00 AM and ≥1:00 AM. Sleep latency was classified into three categories: >30 min, 15–30 min and ≤15 min.

2.2.3. Student-life stress inventory (SLSI)

SLSI is a reliable and valid inventory that investigates students' stress level [27]. This questionnaire consists of 51 items under nine categories. Five categories are about types of stressors (frustrations, conflicts, pressures, changes, and self-imposed), and the remaining four are about reactions to stressors (physiological, emotional, behavioral, and cognitive). Each item is scored on a 5-point scale. The total SLSI score is the sum of the 51 items, which is positively associated with students' stress level.

2.2.4. Assessment of FBDs

Digestive symptoms were evaluated by Rome IV Diagnostic Questionnaire for Adult Functional Gastrointestinal Disorders, a questionnaire consists of questions understandable to researchers and most patients, which is suitable for epidemiological investigation and clinical screening [28]. Rome IV criteria was used for the assessment of IBS and FC. Assessment of IBS was based on 5 questions about abdominal pain, defecation and duration of symptoms. To diagnose IBS, participants must have recurrent abdominal pain for at least three months in past six months, with two or more of the following symptoms: related to defecation, associated with a change in stool frequency, or associated with a change in stool form. Assessment of FC was based on 10 questions about defecation and duration of symptoms. To diagnose FC, participants must have two or more of the following symptoms for at least three months in past six months: straining with defecation, lumpy or hard stools, sensation of incomplete evacuation, sensation of anorectal obstruction/blockage, manual maneuvers to facilitate defecation, or fewer than three defecation per week. FC was diagnosed only if loose stools are rarely present without using laxatives and participants do not fulfill the criteria for IBS.

2.3. Statistical analysis

Continuous variables were presented as means ± standard deviation (SD) for normally distributed data or medians (interquartile ranges) for non-normally distributed data, and compared using analysis of variance or Kruskal–Wallis tests according to data distribution. Categorical variables were presented as percentages (%), and tested through χ^2 tests or Fisher's exact tests. Odds ratios (OR) were used to assess the association between sleep dimensions and IBS or FC. Variables with P value < 0.1 in univariate logistic regression analysis were entered into the multivariate analysis, and

OR and 95% confidence intervals (CI) were calculated. We controlled cofounding factor sex in the multivariate logistic regression model. All statistical analyses were performed using SPSS version 23.0 (IBM Corp., Armonk, NY, USA), and tests of statistical significance were set at P value < 0.05.

3. Results

3.1. Prevalence of FBDs and characteristics of participants

3389 out of 4000 questionnaires were collected finally, then 54 were excluded due to lack of information on diagnosis of FBDs. As a result, a total of 3335 individuals were included in this study (83.4% response rate). The overall prevalence of IBS and FC in college freshmen were 2.5% and 1.7%, respectively. For male students, the prevalence of IBS and FC were 2.4% and 1.2%, respectively. For female students, the prevalence of IBS and FC were 2.5% and 3.5%, respectively.

Table 1 shows the characteristics of the study participants. The age of participants ranged from 15.9 to 23.1 years, with a median age of 18.3 years, and 78.2% of them were male. The proportion of female students in FC group was the highest among groups (P < 0.001). Participants with a history of smoking and drinking were rare, and no statistically significant difference was found among groups. Moreover, students with IBS and FC had higher SLSI scores compared with normal group (P < 0.001), indicating high stress level in FBDs.

3.2. Prevalence of FBDs according to sleep dimensions

We next compared prevalence of IBS and FC according to different sleep dimensions including sleep quality, sleep duration, sleep timing, and sleep latency (Table 2). Compared with individuals reporting good sleep quality, those reporting worse sleep quality had significant higher prevalence of IBS (P < 0.001) and FC (P < 0.001). Individuals with shorter sleep latency showed a tendency of decreased IBS rates (P = 0.060). Additionally, FC was more prevalent in students with shorter sleep duration, though not statistically significant (P = 0.071). Moreover, prevalence of FBDs according to sleep timing showed no significant difference.

Table 1
Characteristics of the study participants.

Variables	Total	IBS	FC	Normal	P value
Number (%)	3335 (100.0)	82 (2.5)	57 (1.7)	3196 (95.8)	
Age (yr)	18.3 (17.9–18.7)	18.2 (18.0–18.6)	18.5 (18.1–18.6)	18.3 (17.9–18.7)	0.540
Sex (%)					<0.001
Male	2576 (78.2)	63 (2.4)	32 (1.2)	2481 (96.4)	
Female	717 (21.8)	18 (2.5)	25 (3.5)	674 (94.0)	
BMI (kg/m^2)	21.2 (19.2–23.7)	20.7 (18.9–22.6)	20.6 (18.7–23.4)	21.2 (19.3–23.7)	0.110
Smoking status (%)					1.000
Current/Former	24 (0.7)	0 (0.0)	0 (0.0)	24 (100.0)	
Nonsmokers	3304 (99.3)	81 (2.5)	57 (1.7)	3166 (95.8)	
Drinking status (%)					0.578
Current/Former	62 (1.9)	0 (0.0)	1 (1.6)	61 (98.4)	
Nondrinkers	3252 (98.1)	82 (2.5)	56 (1.7)	3114 (95.8)	
Regular exercise (%)					0.201
Yes	1895 (57.0)	41 (2.2)	28 (1.5)	1826 (96.3)	
No	1430 (43.0)	41 (2.9)	29 (2.0)	1360 (95.1)	
SLSI (points)	107.0 (93.0–123.0)	119.0 (107.0–133.0)	118.0 (106.3–126.8)	106.0 (93.0–122.0)	<0.001

Note: IBS, irritable bowel syndrome; FC, functional constipation; BMI, body mass index; SLSI, student-life stress inventory. Sample sizes for variables may not equal the total due to missing data.
Continuous variables were presented as means ± standard deviation (SD) for normally distributed data or medians (interquartile ranges) for non-normally distributed data, and differences were analyzed with analysis of variance or Kruskal–Wallis tests. Categorical variables were presented as percentages (%), and differences were analyzed with χ^2 tests or Fisher's exact tests.

Table 2
Prevalence of IBS and FC according to different sleep dimensions.

Variables	Number (%)	IBS (%)	P value	Number (%)	FC (%)	P value
Sleep quality			<0.001			<0.001
Good	1737 (52.6)	25 (1.4)		1737 (52.6)	19 (1.1)	
Fair	1452 (44.0)	42 (2.9)		1452 (44.0)	31 (2.1)	
Poor	114 (3.4)	12 (10.5)		114 (3.4)	7 (6.1)	
Sleep duration			0.414			0.071
>8 h	332 (10.2)	8 (2.4)		332 (10.2)	3 (0.9)	
7–8 h	1251 (38.3)	24 (1.9)		1251 (38.3)	15 (1.2)	
6–7 h	1409 (43.1)	39 (2.8)		1409 (43.1)	30 (2.1)	
≤6 h	275 (8.4)	9 (3.3)		275 (8.4)	8 (2.9)	
Sleep timing			0.157			0.334
<11:00 PM	176 (5.3)	1 (0.6)		176 (5.3)	3 (1.7)	
11:00 PM-12:00 PM	1854 (56.1)	42 (2.3)		1854 (56.1)	28 (1.5)	
12:00 PM-1:00 AM	1176 (35.6)	36 (3.1)		1176 (35.6)	26 (2.2)	
≥1:00 AM	97 (3.0)	1 (1.0)		97 (3.0)	0 (0.0)	
Sleep latency			0.060			0.253
>30 min	116 (3.6)	5 (4.3)		116 (3.6)	4 (3.4)	
15–30 min	811 (25.0)	27 (3.3)		811 (25.0)	15 (1.8)	
≤15 min	2314 (71.4)	48 (2.1)		2314 (71.4)	35 (1.5)	

Note: IBS, irritable bowel syndrome; FC, functional constipation.
Data were presented as percentages (%), and differences were analyzed with χ^2 tests or Fisher's exact tests.

3.3. Association between sleep dimensions and FBDs

To further assess the association of sleep dimensions with IBS or FC, several potential risk factors were analyzed simultaneously via univariate and multivariate logistic regression models, as shown in Table 3 and Table 4. Univariate analysis indicated that self-reported poor sleep quality was associated with increased risk of IBS. After adjusting potential risk factors including sex, BMI and SLSI score in a multivariate analysis, results showed that compared with individuals reporting good sleep quality, those reporting poor (OR = 7.269, 95%CI: 2.876–18.370) had higher risk of IBS. Multivariate analysis also showed that SLSI score was independently associated with IBS (OR = 1.199, 95%CI: 1.066–1.349), and the risk of IBS would increase by 19.9% for each additional 10 SLSI points.

As for FC, univariate analysis indicated that poor sleep quality and short sleep duration (≤6 h) were potential risk factors for FC. After adjustments for sex and SLSI score, results showed that individuals reporting fair sleep quality (OR = 2.068, 95%CI: 1.010–4.236) and poor sleep quality (OR = 5.664, 95%CI: 1.864–17.205) had higher risk of FC compared with those reporting good sleep quality. However, there was no statistically significant association between sleep duration and FC in the multivariate model. Furthermore, multivariate analysis found that female gender was an independent predictor of FC (OR = 2.619, 95%CI: 1.370–5.007).

4. Discussion

In the present study, our results demonstrated that the prevalence of IBS and FC defined by Rome IV criteria in college freshmen were 2.5% and 1.7%, respectively. We also showed that self-reported poor sleep quality was associated with increased risk of IBS and FC among college freshmen while other sleep dimensions not.

Our finding that poor sleep quality was an independent risk factor for IBS and FC is consistent with previous studies [17–19], although our study was carried out in college freshmen, who have just finished their high school life. Under the huge pressure of college entrance examination, the population we studied has been shown to display high prevalence of subjective poor sleep quality, daytime dysfunction and sleep pattern disruption [29,30].

Table 3
Risk factors for IBS by univariate and multivariate logistic regression analysis.

Variables	Univariate analysis		Multivariate analysis	
	OR (95%CI)	*P* value	OR (95%CI)	*P* value
Age (yr)	0.990 (0.696–1.407)	0.955		
Sex				
Male	1 (ref.)		1 (ref.)	
Female	1.027 (0.604–1.746)	0.921	1.138 (0.587–2.206)	0.703
BMI (kg/m^2)	0.913 (0.839–0.993)	0.035	0.915 (0.830–1.009)	0.074
Regular exercise				
Yes	1 (ref.)			
No	1.335 (0.861–2.096)	0.197		
SLSI (per 10 points)	1.202 (1.093–1.322)	<0.001	1.199 (1.066–1.349)	0.003
Sleep quality				
Good	1 (ref.)		1 (ref.)	
Fair	2.040 (1.237–3.363)	0.005	1.906 (1.000–3.636)	0.050
Poor	8.056 (3.934–16.497)	<0.001	7.269 (2.876–18.370)	<0.001
Sleep latency				
>30 min	1 (ref.)			
15–30 min	0.765 (0.288–2.026)	0.589		
≤15 min	0.470 (0.184–1.205)	0.116		

Note: IBS, irritable bowel syndrome; BMI, body mass index; SLSI, student-life stress inventory.

Table 4
Risk factors for FC by univariate and multivariate logistic regression analysis.

Variables	Univariate analysis		Multivariate analysis	
	OR (95%CI)	*P* value	OR (95%CI)	*P* value
Age (yr)	1.266 (0.873–1.835)	0.214		
Sex				
Male	1 (ref.)		1 (ref.)	
Female	2.872 (1.691–4.879)	<0.001	2.619 (1.370–5.007)	0.004
BMI (kg/m^2)	0.983 (0.893–1.081)	0.723		
Regular exercise				
Yes	1 (ref.)			
No	1.380 (0.817–2.331)	0.228		
SLSI (per 10 points)	1.154 (1.021–1.304)	0.022	1.086 (0.951–1.240)	0.221
Sleep quality				
Good	1 (ref.)		1 (ref.)	
Fair	1.973 (1.110–3.507)	0.021	2.068 (1.010–4.236)	0.047
Poor	5.915 (2.433–14.380)	<0.001	5.664 (1.864–17.205)	0.002
Sleep duration				
>8 h	1 (ref.)		1 (ref.)	
7–8 h	1.331 (0.383–4.625)	0.653	1.570 (0.338–7.290)	0.565
6–7 h	2.386 (0.724–7.865)	0.153	2.628 (0.608–11.360)	0.196
≤6 h	3.286 (0.863–12.507)	0.081	3.186 (0.629–16.124)	0.161

Note: FC, functional constipation; BMI, body mass index; SLSI, student-life stress inventory.

However, the contributed role of sleep in FBDs was less studied in this specific population, and our study has confirmed it. The mechanisms underlying the association of sleep quality with FBDs have not yet been elucidated. It has been demonstrated that poor sleep quality had adverse effects on autonomic nervous function, visceral sensitivity and inflammatory cytokines [31–33], all of which were suggested to be associated with increased risk of FBDs. In this study, no statistically significant association was found between other sleep dimensions (sleep duration, sleep timing, or sleep latency) and FBDs. A recent study indicated that self-reported sleep quality showed the strongest association with health outcomes in young adults [34]. Our study provided epidemiological evidence for this conclusion, and suggested that sleep quality may be a more important predictor of FBDs than other sleep dimensions. Therefore, educators and physicians should realize that not merely enough sleep duration and appropriate sleep timing are warranted for the prevention of FBDs in adolescents, improvement of sleep quality also matters.

The investigation in college and university students of North China showed that the prevalence of IBS and FC based on Rome III criteria were 8.3% and 5.5% respectively [35], which were higher than ours. The relatively low prevalence in our study may be partially related to the difference in diagnostic criteria. For example, a multinational survey showed that the diagnostic rate of IBS reduced by half after the switch from Rome III to Rome IV criteria [36]. Moreover, lifestyle habits of college freshmen are relatively fixed and homogeneous, so they may have less risk factors for FBDs.

Our research also showed that stress was associated with increased risk of FBDs among college freshmen. Interestingly, a previous study found that psychological disorders such as anxiety and depression were associated with sleep disorder [37], which means psychological stress and sleep may have some more complex joint effects on the risk of FBDs. Consistent with many previous studies [2,3,36], our results also indicated that female gender had higher risk of FBDs than male, though the association was not statistically significant in IBS. One explanation for this is the difference in population studied. In addition, it is worth noting that the IBS rate in women differs according to geographic location, and female predominance of IBS may no longer exist in Asian regions [38].

To our knowledge, the present study is the first to explore the association between different sleep dimensions and FBDs in a relatively large sample of adolescent college freshmen. However, several limitations should also be acknowledged. First, this is a cross-sectional study, so a causal association between sleep quality and FBDs could not be inferred. Second, this study was conducted in a single university, which may lead to selection bias. Studies performed in multiple centers are needed to verify our findings.

5. Conclusion

In summary, our study reveals that self-reported poor sleep quality is a stronger independent predictor of FBDs than other sleep dimensions among Chinese college freshmen. Future intervention studies should consider improving the sleep quality of adolescents in prevention of FBDs.

Author contributions

Shu Xu analyzed the data and drafted the manuscript. Can Chen, Zhen Ouyang, Chaofan Duan and Zhiyue Xu participated in data collecting, entry and analysis of the data. Xiaohua Hou revised the manuscript critically for important intellectual content. Tao Bai designed, supervised the study and revised the manuscript as the corresponding author.

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Conflict of interest

The authors declare that they have no conflict of interest.

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References

[1] Mearin F, Lacy BE, Chang L, et al. Bowel disorders. Gastroenterology 2016. https://doi.org/10.1053/j.gastro.2016.02.031. PMID: 27144627.
[2] Lovell RM, Ford AC. Global prevalence of and risk factors for irritable bowel syndrome: a meta-analysis. Clin Gastroenterol Hepatol 2012;10(7):712–21. https://doi.org/10.1016/j.cgh.2012.02.029. PMID: 22426087.
[3] Suares NC, Ford AC. Prevalence of, and risk factors for, chronic idiopathic constipation in the community: systematic review and meta-analysis. Am J Gastroenterol 2011;106(9):1582–91. https://doi.org/10.1038/ajg.2011.164. PMID: 21606976.
[4] Lewis ML, Palsson OS, Whitehead WE, et al. Prevalence of functional gastrointestinal disorders in children and adolescents. J Pediatr 2016;177:39–43. https://doi.org/10.1016/j.jpeds.2016.04.008. PMID: 27156185.
[5] Peralta-Palmezano JJ, Guerrero-Lozano R. Prevalence of functional gastrointestinal disorders in school children and adolescents. Korean J Gastroenterol 2019;73(4):207–12. https://doi.org/10.4166/kjg.2019.73.4.207. PMID: 31030457.
[6] Sagawa T, Okamura S, Kakizaki S, et al. Functional gastrointestinal disorders in adolescents and quality of school life. J Gastroenterol Hepatol 2013;28(2):285–90. https://doi.org/10.1111/j.1440-1746.2012.07257.x. PMID: 22988951.
[7] Hoekman DR, Rutten JM, Vlieger AM, et al. Annual costs of care for pediatric irritable bowel syndrome, functional abdominal pain, and functional abdominal pain syndrome. J Pediatr 2015;167(5):1103–8. https://doi.org/10.1016/j.jpeds.2015.07.058. PMID: 26329806.
[8] Wang B, Duan R, Duan L. Prevalence of sleep disorder in irritable bowel syndrome: a systematic review with meta-analysis. Saudi J Gastroenterol 2018;24(3):141–50. https://doi.org/10.4103/sjg.SJG_603_17. PMID: 29652034.
[9] Wu S, Chen S, Zhao Y, et al. Association between excessive daytime sleepiness and functional gastrointestinal disorders: a population-based study in China. J Neurogastroenterol Motil 2017;23(2):298–305. https://doi.org/10.5056/jnm16056. PMID: 27756121.
[10] Cremonini F, Camilleri M, Zinsmeister AR, et al. Sleep disturbances are linked to both upper and lower gastrointestinal symptoms in the general population. Neuro Gastroenterol Motil 2009;21(2):128–35. https://doi.org/10.1111/j.1365-2982.2008.01181.x. PMID: 18823289.
[11] Codoñer-Franch P, Gombert M. Circadian rhythms in the pathogenesis of gastrointestinal diseases. World J Gastroenterol 2018;24(38):4297–303. https://doi.org/10.3748/wjg.v24.i38.4297. PMID: 30344415.
[12] Bishehsari F, Levi F, Turek FW, et al. Circadian rhythms in gastrointestinal health and diseases. Gastroenterology 2016;151(3):e1–5. https://doi.org/10.1053/j.gastro.2016.07.036. PMID: 27480174.
[13] Ali T, Choe J, Awab A, et al. Sleep, immunity and inflammation in gastrointestinal disorders. World J Gastroenterol 2013;19(48):9231–9. https://doi.org/10.3748/wjg.v19.i48.9231. PMID: 24409051.
[14] Park H, Chiang JJ, Bower JE, et al. Sleep and inflammation during adolescents' transition to young adulthood. J Adolesc Health 2020;67(6):821–8. https://doi.org/10.1016/j.jadohealth.2020.04.015. PMID: 32586679.
[15] Gamble KL, Berry R, Frank SJ, et al. Circadian clock control of endocrine factors. Nat Rev Endocrinol 2014;10(8):466–75. https://doi.org/10.1038/nrendo.2014.78. PMID: 24863387.
[16] Gao T, Wang Z, Dong Y, et al. Role of melatonin in sleep deprivation-induced intestinal barrier dysfunction in mice. J Pineal Res 2019;67(1):e12574. https://doi.org/10.1111/jpi.12574. PMID: 30929267.
[17] Zhou HQ, Yao M, Chen GY, et al. Functional gastrointestinal disorders among adolescents with poor sleep: a school-based study in Shanghai, China. Sleep Breath 2012;16(4):1211–8. https://doi.org/10.1007/s11325-011-0635-5. PMID: 22203339.
[18] Lei WY, Chang WC, Wong MW, et al. Sleep disturbance and its association with gastrointestinal symptoms/diseases and psychological comorbidity. Digestion 2019;99(3):205–12. https://doi.org/10.1159/000490941. PMID: 30179863.
[19] Lim SK, Yoo SJ, Koo DL, et al. Stress and sleep quality in doctors working on-call shifts are associated with functional gastrointestinal disorders. World J

Gastroenterol 2017;23(18):3330–7. https://doi.org/10.3748/wjg.v23.i18.3330. PMID: 28566894.
[20] Kim HI, Jung SA, Choi JY, et al. Impact of shiftwork on irritable bowel syndrome and functional dyspepsia. J Kor Med Sci 2013;28(3):431–7. https://doi.org/10.3346/jkms.2013.28.3.431. PMID: 23487413.
[21] Gradisar M, Gardner G, Dohnt H. Recent worldwide sleep patterns and problems during adolescence: a review and meta-analysis of age, region, and sleep. Sleep Med 2011;12(2):110–8. https://doi.org/10.1016/j.sleep.2010.11.008. PMID: 21257344.
[22] Kuula L, Gradisar M, Martinmäki K, et al. Using big data to explore worldwide trends in objective sleep in the transition to adulthood. Sleep Med 2019;62:69–76. https://doi.org/10.1016/j.sleep.2019.07.024. PMID: 31563008.
[23] Liu X, Zhao Z, Jia C, et al. Sleep patterns and problems among Chinese adolescents. Pediatrics 2008;121(6):1165–73. https://doi.org/10.1542/peds.2007-1464. PMID: 18519486.
[24] Owens J. Insufficient sleep in adolescents and young adults: an update on causes and consequences. Pediatrics 2014;134(3):e921–32. https://doi.org/10.1542/peds.2014-1696. PMID: 25157012.
[25] Telzer EH, Goldenberg D, Fuligni AJ, et al. Sleep variability in adolescence is associated with altered brain development. Dev Cogn Neurosci 2015;14:16–22. https://doi.org/10.1016/j.dcn.2015.05.007. PMID: 26093368.
[26] Kansagra S. Sleep disorders in adolescents. Pediatrics 2020;145(Suppl 2). https://doi.org/10.1542/peds.2019-2056I. PMID: 32358212.
[27] Gadzella BM. Student-Life Stress Inventory: identification of and reactions to stressors[J]. Psychol Rep 1994;74(2):395–402. https://doi.org/10.2466/pr0.1994.74.2.395. PMID: 8197278.
[28] Palsson OS, Whitehead WE, van Tilburg MA, et al. Rome IV diagnostic questionnaires and tables for investigators and clinicians. Gastroenterology 2016. https://doi.org/10.1053/j.gastro.2016.02.014. PMID: 27144634.
[29] Liu B, Gao F, Zhang J, et al. Sleep quality of students from elementary school to university: a cross-sectional study. Nat Sci Sleep 2020;12:855–64. https://doi.org/10.2147/nss.S266493. PMID: 33154689.
[30] Luo DM, Xu RB, Hu PJ, et al. Analysis on the current situation of insufficient sleep and its association with physical exercise among Chinese Han students aged 9-18 years in 2014. Zhonghua Liuxingbingxue Zazhi 2018;39(10):1298–302. https://doi.org/10.3760/cma.j.issn.0254-6450.2018.10.002. PMID: 30453426.
[31] Miglis MG. Autonomic dysfunction in primary sleep disorders. Sleep Med 2016;19:40–9. https://doi.org/10.1016/j.sleep.2015.10.001. PMID: 27198946.
[32] Schey R, Dickman R, Parthasarathy S, et al. Sleep deprivation is hyperalgesic in patients with gastroesophageal reflux disease. Gastroenterology 2007;133(6):1787–95. https://doi.org/10.1053/j.gastro.2007.09.039. PMID: 18054551.
[33] Irwin MR. Sleep and inflammation: partners in sickness and in health. Nat Rev Immunol 2019;19(11):702–15. https://doi.org/10.1038/s41577-019-0190-z. PMID: 31289370.
[34] Muzni K, Groeger JA, Dijk DJ, et al. Self-reported sleep quality is more closely associated with mental and physical health than chronotype and sleep duration in young adults: a multi-instrument analysis. J Sleep Res 2021;30(1):e13152. https://doi.org/10.1111/jsr.13152. PMID: 32783404.
[35] Dong YY, Chen FX, Yu YB, et al. A school-based study with Rome III criteria on the prevalence of functional gastrointestinal disorders in Chinese college and university students. PloS One 2013;8(1):e54183. https://doi.org/10.1371/journal.pone.0054183. PMID: 23349820.
[36] Palsson OS, Whitehead W, Törnblom H, et al. Prevalence of Rome IV functional bowel disorders among adults in the United States, Canada, and the United Kingdom. Gastroenterology 2020;158(5):1262–73. https://doi.org/10.1053/j.gastro.2019.12.021. PMID: 31917991.
[37] Bouchoucha M, Mary F, Bon C, et al. Sleep quality and functional gastrointestinal disorders. A psychological issue. J Dig Dis 2018;19(2):84–92. https://doi.org/10.1111/1751-2980.12577. PMID: 29316246.
[38] Lovell RM, Ford AC. Effect of gender on prevalence of irritable bowel syndrome in the community: systematic review and meta-analysis. Am J Gastroenterol 2012;107(7):991–1000. https://doi.org/10.1038/ajg.2012.131. PMID: 22613905.